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Survey of Foreign Activity in Non-Nuclear Energy Technologies

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STIC-78-004

June 1978

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SURVEY OF FOREIGN ACTIVITY IN NON-NUCLEAR ENERGY TECHNOLOGIES (U)

STIC-78-004
June 1978

SCIENTIFIC AND TECHNICAL INTELLIGENCE COMMITTEE

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FOSSIL ENERGY

SURVEY OF FOREIGN ACTIVITY IN NON-NUCLEAR ENERGY TECHNOLOGIES

FOSSIL ENERGY

- Coal and Oil Extraction Technology
- Direct Coal Combustion
- Coal Liquefaction
- High-Btu Coal Gasification
- Low-Btu Coal Gasification
- In-Situ Coal Gasification
- Magnetohydrodynamics
- Advanced Power Systems
- Gas and Oil Extraction
- In-Situ Oil Shale

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Coal and Oil Extraction Technology

A US objective is to develop, test, and demonstrate (economically and environmentally acceptable) new and improved technologies to extract coal and oil shale. The US Bureau of Mines supports R&D on new automated and high-speed mining techniques. 25X1

Poland, the United Kingdom, West Germany, and, to some extent, France are emphasizing increased mining efficiency and developing automated mining techniques and large-scale mining equipment. West Germany is improving its strip-mining techniques. Poland and the United Kingdom are studying environmental problems related to coal mining. Poland's mining technology and related environmental programs should be useful to US coal extraction programs. Canada is supporting research on extracting oil sands and has a plant producing oil from oil sands.

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Direct Coal Combustion

The United States plans to develop coal-oil slurry combustion and other direct combustion systems and to evaluate the reliability and efficiency of present boiler systems. Of the direct combustion systems studied, fluidized-bed combustion appears to be receiving the most attention even though this type of system, which uses coal of all ranks, quality, and sulfur content, is not yet economical, practical, or environmentally acceptable.

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To improve direct combustion processes, Australia and Canada are working on problems related to drying and pulverizing coal and to environmental concerns which include particulate matter and sulfur dioxide emissions.

The United States, West Germany, and the United Kingdom jointly are studying fluidized-bed combustion to provide data and technical support for large-scale prototype combustors; they will assess the capabilities and limitations of pressurized fluidized-bed combustion and exchange information on other research in this area. South Africa is studying fluidized-bed combustion techniques and West Germany is conducting supporting studies to determine the conversion ratio of different kinds of coal combustion. The Soviets are beginning to develop fluidized-bed combustion systems (see section on Advanced Power Systems). France is commercializing the Ignifluid boiler which employs fluidized bed combustion.

Coal Liquefaction

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To develop second-generation coal liquefaction technology, the United States is supporting the development of a number of coal liquefaction processes through the pilot-plant stage; the most efficient process or combination of processes will be selected for commercial application. 25X1

Australia has an immediate need for heavy fuel oil and is developing a flash pyrolysis technique that can be scaled to plant size in 10 years. West Germany is a world leader in coal liquefaction technology and currently is working to improve hydrogenation processes. West Germany plans to build pilot plants to produce heavy heating oils and middle distillates; its bench-scale tests on catalysts and reaction conditions should prove to be important to the United States. Poland is operating a pilot plant for solvent-refined coal. The United Kingdom is planning pilot-plant tests on hydrogenation techniques; its studies on supercritical gas extraction of coal and on pyrolysis appear promising. Japan's solvolysis process for heavy oils is in the pilot stage. One South African commercial-scale plant [1] has been converting coal to gas and oil since 1955, and currently, South Africa is expanding its commercial-scale operations. In addition, it is conducting supporting hydrogenation studies on coal and its products. The USSR is developing high speed pyrolysis processes through a number of pilot plants and is also developing a hydrogenation process for coal and oil mixtures. 25X1 25X1

High-Btu Coal Gasification

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The United States is moving as rapidly as possible to develop a number of second-generation coal gasification processes and in the 1980s plans to have the technology at the demonstration or commercial scale level. Advances resulting from development of second generation technology will be used to increase the operational efficiency of first generation processes now available. 25X1 25X1

Results from Japan's work on fluidized-bed and plasma gasification and supporting studies to understand fundamental gasification reactions should be of interest to the United States. West Germany is conducting extensive research in high-Btu gasification processes, including fixed and fluidized-bed gasifiers, and is planning to construct a number of pilot plants in the near future. Work in the United Kingdom has increased considerably the operating range of the

[1] South African Coal, Oil, and Gas Cooperation (SASOL)

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Lurgi process to produce synthetic natural gas from coal; this has led to studies on char gasification and pyrolysis. The Netherlands is doing research on high-pressure gasification, coal slurry handling, and catalysis. Newcomers to the field include Canada and Yugoslavia, which plan to make better use of their domestic coal reserves through gasification.

Low-Btu Coal Gasification [redacted]

[redacted] The United States is developing gasifiers and hot gas cleanup systems that operate at atmospheric and elevated pressures. It is also developing various techniques (e.g., fixed bed, entrained-bed, and molten salt) simultaneously to permit comparison and evaluation of different gasification methods.

25X1 [redacted] West German gasifiers such as the Lurgi and Winkler units are in production and are used widely in various commercial installations. West Germany is building a prototype coal gasification plant using a high pressure process capable of converting 150 tons of coal per day to low-Btu gas without by-products. Japan currently is testing a 5-ton-per-day, low-Btu gasification plant to generate power. The plant is also being used for desulfurization testing. It is constructing a 40-ton-per-day plant. The United Kingdom is doing research on fluidized-bed gasification to produce low-Btu gas to generate power. The Soviet Union has been testing a "new" fluidized bed gasification pilot plant which has a coal feed rate of 50 to 100 tons per hour and produces a low-Btu gas.

In-Situ Coal Gasification [redacted]

[redacted] The United States plans to develop and demonstrate commercial technology to convert in-situ coal to low- and medium-Btu gas. Process development unit tests will be followed by scale-up to pilot-plant level using multiple modules. Success has been achieved with the linked vertical well technique, similar to the Soviet process.

[redacted] The USSR has been operating many in-situ coal gasification plants since 1933, but has been reducing activity dramatically since the late 1960s. More recently, the technical and economic problems involved have further reduced Soviet interest in in-situ coal gasification. However, the Soviets are selling their know-how in this technology to an association of electricity producers in Texas. Belgium and West Germany are jointly studying the feasibility of gasifying coal underground to produce low-Btu fuel gas. If successful, experiments will be conducted to hydrogasify underground coal directly to yield a pipeline-quality substitute for natural gas. The results from their efforts could be adapted to US in-situ coal gasification. 25X1 25X1

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Magnetohydrodynamic Technology [redacted]

[redacted] The US program emphasizes developing MHD electrical generators (using coal as the primary fuel) to augment commercial-size electric power plants. When combined with conventional stream power systems, MHD could significantly improve the overall thermal efficiency of power systems. The United States plans to design and test MHD components and subsystems in pilot-scale facilities by 1985 and to develop and operate a commercial-scale MHD electric power plant, fueled by coal, by the year 2000. 25X1

[redacted] The USSR is operating the world's largest MHD facility, its U-25 pilot plant. As part of the US-USSR MHD cooperative program, equipment developed by the United States will be tested in the U-25 facility. A US MHD channel will be tested and will be used for joint high-field generator experiments. Soviet-designed equipment will be tested in US coal combustion facilities. These tests should provide significant data for US MHD efforts. 25X1 25X1

[redacted] Japan, Poland, the Netherlands, and several other European nations are developing MHD technology that may be important to the US program. Particular attention should be given to Poland's "enlarged" MHD generator, which uses clean gas from coal, and was to be operating in 1977. France, West Germany, and the United Kingdom have curtailed efforts in MHD because of other national priorities. 25X1 25X1 25X1

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Advanced Power Systems [redacted]

[redacted] The US objective in an open-cycle gas turbine program is to develop key components to incorporate into a prototype advanced high-temperature gas turbine. By the year 2000, the United States plans to implement commercially combined-cycle power plants using high-temperature turbines fueled by coal-derived low-Btu gas. 25X1 25X1

[redacted] West Germany's experience with its 170-MW(e) combined-cycle power plant in Lunen will be the basis for designing a future 800-MW(e) combined-cycle power plant. Japan plans to develop a much smaller combined-cycle plant from its current research. In the Soviet Union, integrated power and coal conversion are being developed on an experimental and industrial scale. At present, the Soviets are constructing near

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Krasnoyarsk a demonstration industrial plant for processing 1.2 million tons of coal a year through flash pyrolysis to provide boiler fuel and by-product chemicals. A Swedish company is seriously considering developing a 70-MW(e) advanced gas turbine power plant to be powered by fluidized bed combustors. The combustors are to be commercial versions of experimental units currently in development in the United Kingdom.

Gas and Oil Extraction [redacted]

[redacted] US R&D on gas and oil extraction emphasizes improving current and developing enhanced recovery extraction techniques for difficult environments such as the Arctic and outer continental shelf. The United States is supporting industrial efforts in this area. Work is under way to develop injection processes, thermal recovery methods, and hydraulic and explosive fracturing techniques. The United States is exchanging information on petroleum extraction technology with Canada, France, West Germany, Italy, Japan, the Netherlands, Switzerland, the United Kingdom, and the USSR.

[redacted] R&D in other industrialized nations also focuses on technology for enhanced recovery. Canada, the Netherlands, Romania, the United Kingdom, and West Germany are developing deep drilling, high-capacity drilling, and enhanced recovery technology. In offshore technology, France, the Netherlands, Romania, and the United Kingdom have active programs to develop drilling platforms, automated rigs, and deep-water drilling. Emphasis in the USSR is on exploring the Arctic, transporting supercooled gas, and constructing large-diameter pipelines. Canada is developing transportation systems to facilitate Arctic exploration. France is developing equipment for exploration in the Arctic. France, Italy, and the United Kingdom are developing large-diameter pipelines that may be important to long-distance transportation of oil and gas. Several nations including Canada, Switzerland, and the United Kingdom are studying the feasibility of storing oil and pressurized gas underground.

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In-Situ Oil Shale Technology [redacted]

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[redacted] The United States is supporting the development of a technological base for a commercial shale oil and gas industry; primary interest will be in oil production. In-situ and modified in-situ (where a portion of the shale is mined before fracturing) methods will be studied. Sustained shale oil production has been demonstrated at shallow depths using in-situ combustion; using explosives to augment hydraulic fracturing at medium depths looks promising.

[redacted] Only limited information from other countries is available on in-situ extraction of oil shale. The People's Republic of China has the world's largest oil shale industry; located in Manchuria, it produces 50,000 barrels of oil per day. The second largest is in the USSR. Romania is building its first electric power plant to use raw shale as a boiler fuel.

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SOLAR ENERGY

- Solar Heating and Cooling of Buildings
- Agricultural and Industrial
  Process Heat
- Solar Thermal Electric Energy
- Photovoltaic Energy
- Solar-Related*
  - Wind Energy
  - Tidal and Wave Energy

* Wind and wave energy are produced indirectly by the energy from the sun. Tidal energy is related to the gravitational attraction of the moon, but is listed here for convenience.

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Solar Heating and Cooling of Buildings [redacted]

[redacted] In solar heating and cooling of buildings, the United States is encouraging the development of industrial and commercial application to reduce demand on fossil fuel supplies.

[redacted] Australia and Japan could be valuable sources of information on operations, production, and sociological aspects of a commercial flat plate solar collector industry; both countries have such an industry and the collectors have been in use for several years. Australia, France, Japan, and the United Kingdom are conducting research on collector and system materials to increase efficiency and decrease costs. West Germany is the lead country in the International Energy Agency cooperative program for testing thermal performance of solar collectors.

[redacted] Significant international research on solar cooling is limited. However, Japan is demonstrating the feasibility of operating a lithium-bromide absorption-cycle cooling system at low generator temperatures (165 degrees F). Israel has developed a solar-powered turbogenerator using novel collector and working-fluid concepts. It also is commercializing a 5-hp turbogenerator that could drive a compressor for space cooling and a generator to produce electric power at remote sites. Japanese and Israeli activities closely parallel US efforts to use low-grade heat from flat plate collectors for space cooling.

Agricultural and Industrial Process Heat [redacted]

[redacted] Application of solar heat to US agricultural and industrial processes would reduce fossil fuel consumption significantly in both sectors.

[redacted] French research on applying solar heat to industrial processes focuses on those processes using high temperatures (up to 3000 degrees C) and on low-grade heat associated with agricultural processing; the results of this research could be important to US efforts in this area.

Solar Thermal Electric Energy [redacted]

[redacted] The United States plans to expedite the development and implementation of commercial-scale solar thermal electric-generating plants and total energy systems using electric and thermal output.

[redacted] France and Japan have programs on solar thermal electric power generation which may be of interest to the United States. Japan is designing and building prototypes of small units (10-kw); France has 1-kw to 25-kw units available commercially and is developing prototypes of 10-MW to 25-MW output. The United States is cooperating with both countries in this area. 25X1 25X1

Photovoltaic Energy [redacted]

[redacted] The United States is the leader in photovoltaic R&D. The major problems facing commercial application of photovoltaic energy conversion are material costs, efficiency of production techniques, and cell conversion efficiency. Japan seems to be the best foreign source for technical information on cost-effective methods for producing silicon-ribbon, single-crystal solar cells. R&D in France and the United Kingdom are related to improved solar cell designs and efficiency. Information on British, French, and Japanese R&D may be useful to the US program. 25X1

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Wind Energy [redacted]

[redacted] The United States is planning to develop and test large wind-powered electrical generators, including vertical-axis machines. The United Kingdom and the USSR have developed commercial-scale systems. British manufacturers produce 200-w to 2-kw units. The USSR has deployed many 1-30kw machines to generate power in areas remote from electric power grids, including the Arctic. Emphasis in the Netherlands is on modeling wind and terrain interactions as criteria for site selection. Efforts by other countries are devoted mainly to basic research on equipment and materials. Canadian and Israeli research on horizontal-axis and vertical-axis rotors has potential value, but commercial application is not widespread. 25X1 25X1

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Tidal and Wave Energy [redacted]

[redacted] The United States is conducting some R&D but has no large-scale experiments under way. France and the USSR have the only operating tidal power stations, although Australia, Canada, and the United Kingdom are considering such stations. France's tidal power plant has a theoretical maximum output of 544-GW annually, and the USSR is planning 2000-MW and 20,000-MW plants. Construction experience and operational data from French and Soviet facilities could prove useful to US research on tidal power plants. Japan and the United Kingdom are developing concepts to generate power from wave motion; practical commercial-scale designs have not been developed. 25X1 25X1 25X1

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GEOTHERMAL ENERGY

- Resource Exploration and Assessment
- Hydrothermal Technology
- Demonstration Projects
- Advanced Technology Applications
- Engineering R&D

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Resource Exploration and Assessment

US efforts in geothermal energy include exploring and assessing geothermal resources; developing and demonstrating improved plant components; and developing technology to improve methods of recovering energy from higher salinity hydrothermal resources, including verifying the use of binary cycles, demonstrating the feasibility of removing with circulating fluids useful energy from hot dry rock sources, and continuing research on extracting energy economically from geopressured zones.

Detailed information on geothermal resources is limited, and fundamental geothermal processes are not understood fully. Some half-dozen countries are exploring for sizable geothermal reserves; improving geochemical, geophysical, and hydrogeological methods; and developing seismicity, resistivity, infrared imagery, temperature-gradient drilling, and other techniques. These technological developments could be useful to the US program, particularly the Italian, Japanese, and Soviet efforts because of their extensive exploratory programs. 25X1

Hydrothermal Technology

The variety of fluid characteristics from different reserves and their impact on the economics of geothermal use require that a variety of test facilities be built. US R&D is under way on electrical and nonelectrical application of hydrothermal resources; the basic problems encountered in US R&D are the same as those experienced in other countries.

Iceland, Italy, and Japan are developing power generation and desalination plants that could provide relevant data to the United States. The USSR is doing significant work on power generation and space heating applications, but the agreement between the US and the USSR on geothermal energy applications is not active. Iceland is expanding its hot water supply system to provide space heating in its capital for three additional communities totaling 75,000 people. France and Italy also are contributing significantly to geothermal technology for heating buildings. Studies of injection-production systems to optimize output are under way in France, Germany, and Japan.

Demonstration Projects

The United States has projects under way to develop further its geothermal resources and is planning two full-scale 50-MW demonstration plants by the mid-1980s.

Iceland, Italy, Japan, and the USSR also have developed geothermal electricity commercially; they are continuing to build additional facilities and increase production in existing geothermal fields. Italy, a pioneer in geothermal use and technology, has been generating geothermal electricity commercially since 1913. Japan has several programs under way to develop technology for dry steam, wet steam, hot water heat exchanger, and hot dry-rock systems. Iceland is building a power station equipped with two Japanese steam turbines (each 30-MW) that will use steam from hot water. Technological developments in Iceland, Italy, Japan, and the USSR should be useful to the United States as it continues to expand and develop its program. However, liquid-dominated commercial generating plants operating outside the United States were not designed to be compatible with and do not meet US environmental standards; therefore, these plants may offer only limited technology transfer opportunities. 25X1 25X1

Advanced Technology Applications 25X1

Initially, the US technology program on advanced geothermal energy focused on the use of geopressured and hot dry rock resources, although some preliminary work was done on normal-gradient and nonassociated radio-genic resources. 25X1

The United States and Italy are jointly exploring ways to fracture hot dry rocks and pump water through the resulting fissures, thus creating new geothermal power sources. Japan also is developing hot dry rock fracturing techniques and has agreed with the United States to exchange information on stimulating hot dry rock reservoirs. The USSR is studying underground thermal regimes and is planning projects using rock heat. 25X1 25X1

Engineering Research and Development

Recent US geothermal R&D programs are beginning to provide prototype hardware for testing. Programs on drilling technology and improving the efficiency of geothermal energy use are continuing.

Italy and the United States are jointly investigating methods to rejuvenate boreholes whose output is diminishing by reinjecting condensate into the rocks. Iceland is developing well-stimulation techniques.

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Results from Japanese and Soviet efforts to improve and develop equipment and materials that can withstand the severe corrosive amd erosive effects of some geothermal brines may be directly applicable to US efforts in this area. Italy and Japan are designing and developing equipment to increase generating output and to improve pipeline networks. The United States is exchanging information on geothermal technological developments with Iceland, Italy, and Japan.

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CONSERVATION

- Electric Energy Systems
- Energy Storage Systens
- Industry Conservation
- Building Conservation
- Transportation Energy Conservation
- Energy Conversion

CONSERVATION

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Electrical Energy Systems

The United States is developing systems to improve network planning and control methods, increase efficiency and environmental acceptability of transmission methods, and test new ideas on operating utility grids.

Italy has similar objectives and is working on a 10-year project to construct a 1000-kv pilot plant with a 15-kilometer line which will be integrated into the present 420-kv system through transforming stations. All system components are to be tested directly in the field before constructing and developing the ultrahigh voltage network. West Germany, Belgium, the USSR, and Yugoslavia are working on network controls and transmission methods. Romania and Poland are doing research on problems involving ultrahigh voltage transmission and ways to reduce electricity consumption.

Energy Storage Systems

The United States is developing energy storage systems to use more fully energy sources whose availability does not coincide with periodic demand. Areas of application include electric load peaking, solar energy, and efficient energy transport. Energy storage R&D in most countries deals with storing pumped water or improving battery design and construction.

The United Kingdom is building one of the world's largest pumped water storage facilities. West Germany's program is innovative and comprehensive, involving several technologies at the state-of-the-art in: batteries, hydrogen, flywheels, compressed air, and thermal studies. Its most interesting projects are using small lakes and ponds with insulating covers to store solar thermal energy and developing hydrogen-carried energy storage and recovery systems. The Netherlands also is developing techniques to store hydrogen energy. East Germany, Poland, and Romania are developing techniques to store electrical energy.

Industry Conservation

The US approach to energy conservation in industry is to analyze processes, operation, and technology to determine where major energy losses occur.

Sweden is effectively developing industrial conservation; the government monitors energy-intensive industries and extensive work is under way using industrial waste heat. Canada, East Germany, Japan, and Poland are studying methods to use waste heat and improve basic processes. 25X1 25X1

Building Conservation

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The US goals for conservation in buildings are: to implement existing and develop new energy-efficient technology; to develop systems to reduce dependence on petroleum and natural gas; and to disseminate information about existing and new energy-efficient technology. 25X1

Canada, France, and West Germany are participating with the United States in a multilateral agreement sponsored by the Committee on the Challenges of Modern Society (CCMS) to exchange information on energy conservation technology. Canada is analyzing total energy systems to increase energy efficiency in buildings. France is concentrating on developing insulation methods, more efficient automatic controls, and heat pumps. West Germany is developing central district heating and heat pump technology. East Germany has developed large central district heating complexes (400,000 apartments) for domestic buildings. Sweden is known for its energy conservation in buildings, but information on its R&D is not readily available. 25X1 25X1 25X1

Transportation Energy Conservation

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The US objective in this area is to improve the efficiency of petroleum-dependent transportation for the short term, to develop nonpetroleum-fueled systems for the long term, and to change usage patterns in the transportation sector. Several projects in other countries could provide useful information to the United States. 25X1 25X1

Canada is studying a high-speed, mass transit system based on using magnetic levitation for low-drag operation. The Netherlands is developing an electric commuter vehicle which could be used in the United States. Other work of interest includes French R&D on electric vehicles and Italian development of methanol-fueled transportation. The Japanese are not only building and exporting efficient petroleum-fueled vehicles, but also are developing electric cars and other advanced propulsion systems. 25X1 25X1 25X1 25X1

Energy Conversion

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Emphasis in the United States is on conversion methods, such as heat exchangers, motors, generators,

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and fuel cells, that have the greatest effect on savings in petroleum and natural gas resources. Special impetus is given to areas with potential short-term results.

The People's Republic of China, France, West Germany, Japan, Romania, and the USSR are developing fuel cells. Little additional information is available. 25X1

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